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Review paper

PIONEERS OF PREFAB ARCHITECTURE – CRYSTAL PALACE AND MAISON CITROHAN

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Abstract

Although prefabricated buildings have long been present in modern civil engineering and architectural practice, they still have strong supporters and opponents. This paper explores the achievements of prefabricated construction in the 19th century and the first half of the 20th century by presenting two significant buildings: Joseph Paxton's Crystal Palace in London from 1851, and Le Corbusier's Maison Citrohan in Stuttgart, developed between 1920 and 1927. These authors and their buildings - each in their own time - pushed the boundaries of prefabricated construction through their authenticity, ideas, visions, applied technologies, and materials, opening the door to a method still in use today.

Keywords: *Prefabrication, Technology, Joseph Paxton's Crystal Palace, Le Corbusie's Maison Citrohan.*

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1. INTRODUCTION

Prefabricated construction is a field in architecture and civil engineering that, since the inception of the very idea, has continuously gone through phases ranging from approval—even euphoria—to disappointment and abandonment. In the ups and downs of prefabrication, civil engineers have primarily focused on solving practical issues, from designing connections, producing large-scale components, and ensuring material quality to developing the machinery necessary for transporting and assembling prefabricated elements. Over time, architects and designers have oscillated between enthusiasm and disdain for this system. Visionaries eagerly await technological innovations and opportunities to break free from conventional spatial design for living and working environments. In contrast, some designers remain reserved and opportunistic, considering buildings constructed this way overly simplistic, standardised, and limited in aesthetic potential.

The concept of prefabrication is subject to various definitions and interpretations over time. At its core, prefabricated construction refers to a building method based on elements produced either in a factory or on-site, which are assembled into a whole at the construction location. As buildings can be constructed from different materials, this definition should encompass all materials, primarily wood, steel, and concrete, as the most common. However, due to the development and widespread use of concrete prefabricated elements in the second half of the 20th century, it is not uncommon for prefabrication to be associated predominantly with factory-made concrete structures.

In a broader sense, buildings that can be defined or categorised as “prefabricated” can be found across the globe throughout different stages of societal development. These structures are typically tied to locally available materials, inherited technologies, and prior advancements. The Mongolian yurt, which dates back to the 13th century, continues to be utilised in contemporary society [1]. In North America, a significant example is the wooden panelling building brought by the English to Cape Ann, Massachusetts, in parts assembled there as early as 1624 [2]. This structure served as housing for a fishing fleet. Due to the nature of the work, which required frequent relocation, these buildings were often disassembled, transported, and reassembled multiple times. It is also important to mention examples from the Western Balkans, where people were forced to move due to unstable living conditions and adapted some of their dwellings to suit a more mobile lifestyle [3].

Although the above-mentioned facilities can be compared to modern prefabricated construction in some ways, they show the importance of having a shelter and property, along with the speed of construction and the ability to relocate structures, either in whole or in part according to current needs, has always been significant. This need has consistently served, as it still does today, as a powerful motivation. This research aims to explore the origins and core principles of prefabricated buildings as we know them today. It is based on analysing relevant literature and case studies focusing on two architectural visionaries: Joseph Paxton and Le Corbusier.

2. IMPORTANT PREFAB BUILDINGS OF THE 19th AND 20th CENTURIES

"The strength of the prefabricated house lies in its popularity, its cheapness and the industrial base from which it operates. These are precisely the areas in which modern architecture is weakest. Modern architecture is unpopular, expensive and divorced from industrial production. This is why whenever it has tried to extend its field to include the territory of the prefabricated house, it has failed and been forced to retreat."
Davies, 2005 [4]

This section presents two significant buildings: Joseph Paxton's Crystal Palace, built in 1851, and Le Corbusier's Maison Citrohan, completed in 1927. Each of these structures, in its own time, pushed the existing boundaries of construction and reshaped the perception of architectural culture in terms of public spaces intended for the masses and private residential environments. Through their innovative approaches, these projects captured the interest of professionals and users alike and contributed to humanity's ongoing pursuit of improving spaces for living and working.

2.1. Crystal Palace

Inspired by the Exhibition of Industrial Achievements held in France in 1849, Prince Albert conceived and initiated, while the Royal Commission organized, the Great Exhibition of the Works of All Nations. The goal was to showcase numerous important innovations from across the globe, resulting from discoveries made during the Industrial Revolution. At a time when Britain and France were engaged in constant competition—even in terms of innovation and technological advancement—this exhibition was the first to include other nations and their inventions. It is considered a forerunner of today's world-renowned EXPO exhibitions. A design competition was announced for the exhibition building that could be located in Hyde Park, requiring a net floor area of 800,000 square feet (74,000 m²) and a maximum budget of £100,000 [5]. The structure was expected not only to impress the world and demonstrate the strength of the British nation but also to be the largest building ever constructed at the time—and cheaper per cubic foot than previously built structures of a similar type.

The time constraints were also challenging: the competition ran from March 13 to April 8, 1850, while the exhibition opening was scheduled for May 1, 1851, leaving less than 13 months for the entire project. An additional challenge was the requirement that the building be dismantled after the exhibition and that the trees in Hyde Park remain untouched. A total of 245 proposals were submitted, including 38 international entries. The Building Committee rejected them as unsuitable or too expensive (some exceeding the proposed budget by up to three times), causing dissatisfaction among several architects.

The situation grew tenser as it had already been announced that Queen Victoria would personally open the exhibition. Only then did the renowned gardener and greenhouse builder Joseph Paxton express interest. With building engineer William Barlow, Paxton quickly submitted a proposal for the exhibition hall (Figure 1a). Since their design met the key criteria—rapid construction, cost-efficiency, and the ability to be dismantled—the Building Committee approved the project on June 20, 1850.

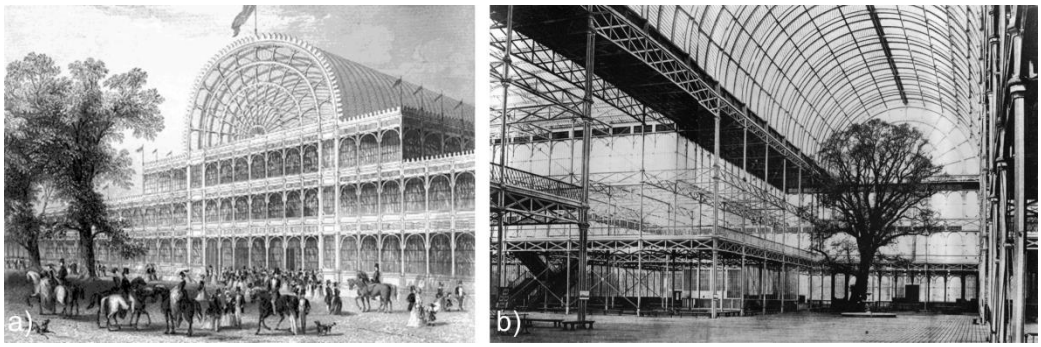

Figure 1. a) Crystal Palace 1851, b) interior with elm tree [6]

The dedication and consistency of the competition organizers is also evident in the episode when the 11th July Committee, while reviewing and approving additional sketches and drawings, requested that the height of the structure be increased by approximately 20 feet (6.1 meters) to avoid cutting down three large elm trees (Figure 1b). This request was fulfilled with the construction of a laminated timber arch system, which had been discovered and patented by J. Paxton ten years earlier. Constructed with cast iron, wood, and glass, the Crystal Palace became the largest building in the world at the time, symbolizing the pinnacle of the First Industrial Revolution's achievements.

At a time when buildings were most often built of stone and clay products, a time-consuming process requiring skilled workers, the Crystal Palace—measuring 564 x 139 x 39 (41) meters—was conceived, designed, all the necessary components manufactured, then transported to the site and assembled, so that the building was fully completed in 39 weeks [7]. Figure 2 compares the traditional construction methods used up to that time with J. Paxton's improved process, showing that the construction of the Crystal Palace was at least three times faster, which was made possible by several important factors: modular construction, industrial production of standard elements and fasteners in factories, and the possibility of continuing and combining standard elements to obtain new elements.

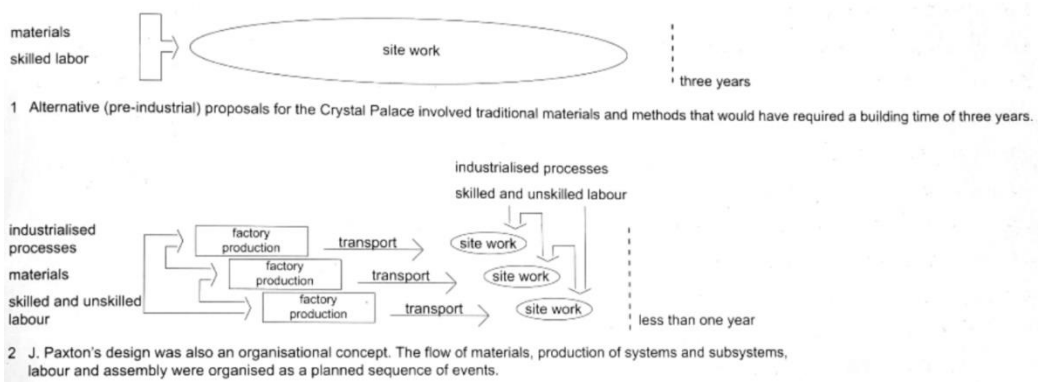

Figure 2. Comparison of pre-industrial and early-industrial production, organization, and assembly of Crystal Palace [7].

The Crystal Palace earned the reputation as the most transparent and light-filled building of its time, thanks to its glass roof and envelope. At the time, glass could only be manufactured in sheets measuring up to 1.25 meters in both dimensions, so the author took glass panes 1.25 x 0.25 meters, requiring more than 293,000 identical panes to complete the building envelope. All the glass panels used were of uniform size. Since Britain's largest glass producer, Chance Brothers (Smethwick), could not fulfil such a large order within the required timeframe, additional glassworks were hired from Saint-Gobain, France.

The glass panels were installed in wooden frames supported by cast-iron trusses and columns, while the foundations were made from concrete. All components were fully prefabricated and mass-produced. These standardized parts were combined with identical or different elements to create new forms. This approach reduced the number of manufacturing elements and increased batch production, leading to an overall cost reduction. The entire structure used just two types of columns, both with the same cross-section: one measuring 22 feet (6.7 m) for the ground floor and the other 20 feet (6.1 m) for the upper levels. Assembly was carried out independently, as all components were self-supporting and were later connected to form the complete structure.

The building featured natural lighting, ventilation, and drainage—characteristics that define sustainable architecture today. Remarkably, the construction did not disturb the existing vegetation in the park; instead, it was preserved and integrated within the building itself. The Crystal Palace was built by a workforce of 2,000 people. At that time, the total construction cost was £80,000 (equivalent to approximately £9.3 million in 2024). During the 5.5-month-long exhibition, the structure attracted six million visitors [5].

Figure 3. Crystal Palace in Sydenham 1928, Historic England Archive. Aerofilm Collection. EPWO21373 [8].

This remarkable structure is considered the true spark of prefabricated construction. After the exhibition, it was dismantled, relocated to Sydenham in southwest London (Figure 3), and reassembled, where it served various functions until it was destroyed by fire on November 30, 1936.

2.2. Maison Citrohan

"The house is a machine for living in." Le Corbusier [9]
"His vision of industrialization and its implementation in architecture is closer to the mythification of an era and his will for progress than to the reality, he leaves on the technological development not only the renovation of architecture, but the revolution of the whole society." Alfonso Diaz Segura [10]

The period after World War I posed a challenge for all areas of life and work, especially for architecture and construction, given the devastated housing stock, mass population migrations, and the urgency of solving these problems. Aware of the current situation and the necessity of new approaches, Le Corbusier emphasizes the following recommendations, considering them important for the future Modern Architecture: an unreserved acceptance of new materials, technologies and construction systems, awareness of new social realities, and he emphasizes that manufacturing had to be based on industrial dynamics with rational and efficient task management [11,12].

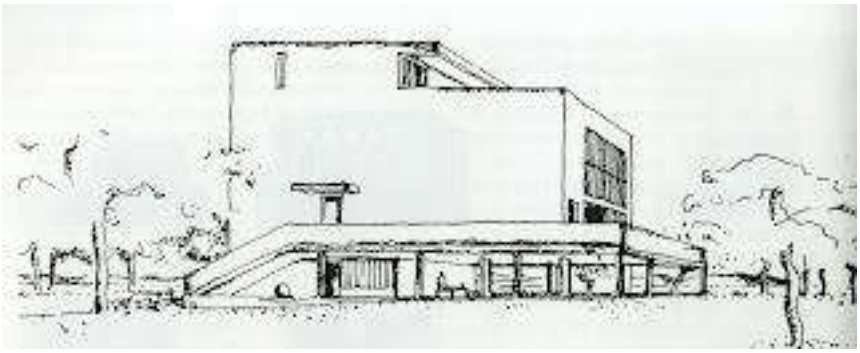

Figure 4. Sketch of Maison Citrohan [13]

As one of the possible solutions to the set requirements, prefabrication, more commonly known as prefabricated architecture, is proposed. Le Corbusier created three basic house prototypes in line with these trends: the Domino, Monol, and Citrohan (Figure 4). The name of the last prototype is provocative and intentionally reminiscent of Citroen, a popular car brand at the time, thus emphasizing the object as a "machine for living." World War I and its consequences significantly influenced the design of these models, so, in addition to aesthetics, the focus was placed on functionality and accessibility for ordinary people to enhance people's daily lives. Maison Citrohan evolved through five versions from 1920 until 1927, each representing an improvement over the previous version. The first version spans three floors and includes everything necessary for a comfortable life for a single person or a family, such as a yard and a usable roof terrace. The idea stems from Parisian painting studios, resulting in a living room with a double-height ceiling and full-height windows facing north. In 1925, for the first time, there was an opportunity to construct these buildings as living units for workers in Pessac, prompting the author to reduce the dimensions and forgo the double-height ceiling. From the foundational idea, with continuous improvements by 1927, Le Corbusier and Pierre Jeanneret designed the fifth version of Maison Citrohan, which was showcased at the famous Weissenhof exhibition in Stuttgart, where it radiated in its full glory and became synonymous with a modern and accessible building (Figure 5).

The evolution of the Maison Citrohan building through five variants in seven years, starting from an idea based on a Parisian painting studio and progressing through a series of improvements, refinements, and simplifications, culminates in the final model. Recognizing industrialism and technology as essential for societal advancement, Le Corbusier envisioned the Citrohan house as efficient and innovative, aimed at enhancing the living conditions of the working class. By creating an efficient design, the houses would be constructed from mass-produced, readily available materials such as concrete, and the factory-produced components would resemble parts on an assembly line, illustrating his concept that the Citrohan house mirrors not only the efficiency of cars but also the very method of production.

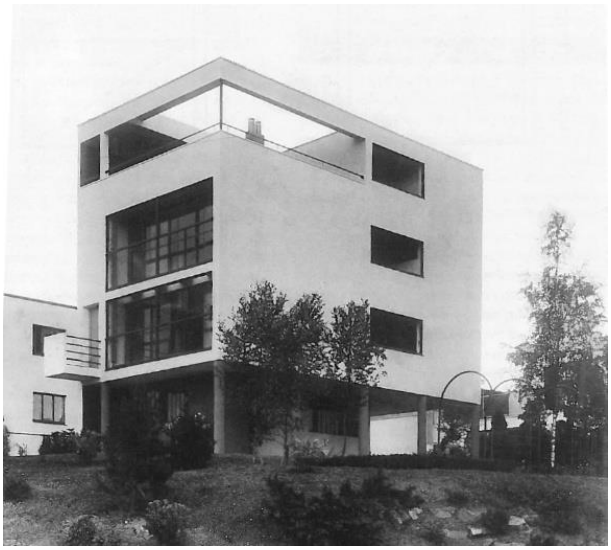

Figure 5. Le Corbusier's Maison Citrohan 1927 [14].

3. CONCLUSION

In contemporary architectural practice, opinions occasionally challenge prefabrication as a construction method regarding certain aspects. However, with the tools available today for designing, manufacturing, and installing prefabricated building elements — from the foundation to the façade systems — the characteristics of prefabrication can now be regarded solely as advantages.

The emergence of modern prefabricated construction, as we define it today, is fundamentally rooted in the Industrial Revolution. Through significant and numerous inventions, the Industrial Revolution transformed the concept of production and, consequently, the construction of buildings themselves. Therefore, prefab architecture results from new technological knowledge, improved processes, and people's willingness to explore, refine, and adapt new concepts to their environments and circumstances.

Today, we must understand prefabrication as a broader concept, especially as technical, technological, and digital innovations have introduced a variety of materials and systems into the market. An additional challenge lies ahead in controlling carbon footprints and the emerging influence of artificial intelligence in this field.

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